Energy Development Center

January 4, 1984

Mr. William E. Muno
Chemical Engineer
Region V
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Muno:

Thank you for your response to our request regarding the shredded x-ray film contaminated with sodium cyanide.

Enclosed with this letter is a document describing the Cyclin incinerator which was jointly developed by the Institute of Gas Technology (IGT) and York-Shipley, Inc. (Y-S). The Cyclin incinerator represents a new concept in waste destruction that achieves improved performance at lower cost.

We would like to take the opportunity to introduce to you the Cyclin incinerator and indicate the availability of a pilot system for testing in specific applications. At the same time we would like to invite you and others from the Environmental Protection Agency to visit, at your convenience, our pilot plant facility located at the Energy Development Center at the address below.

If you have any questions, please feel free to call either myself (890-6440) or Mark Khinkis (890-6445).

Sincerely,

Vladimir Kunc

Vladimir Kunc
Applied Combustion Research

VK/pp

Enclosure

SPECIALIZING IN ENERGY R & D FOR OVER 35 YEARS

IGT
EDUCATION · RESEARCH

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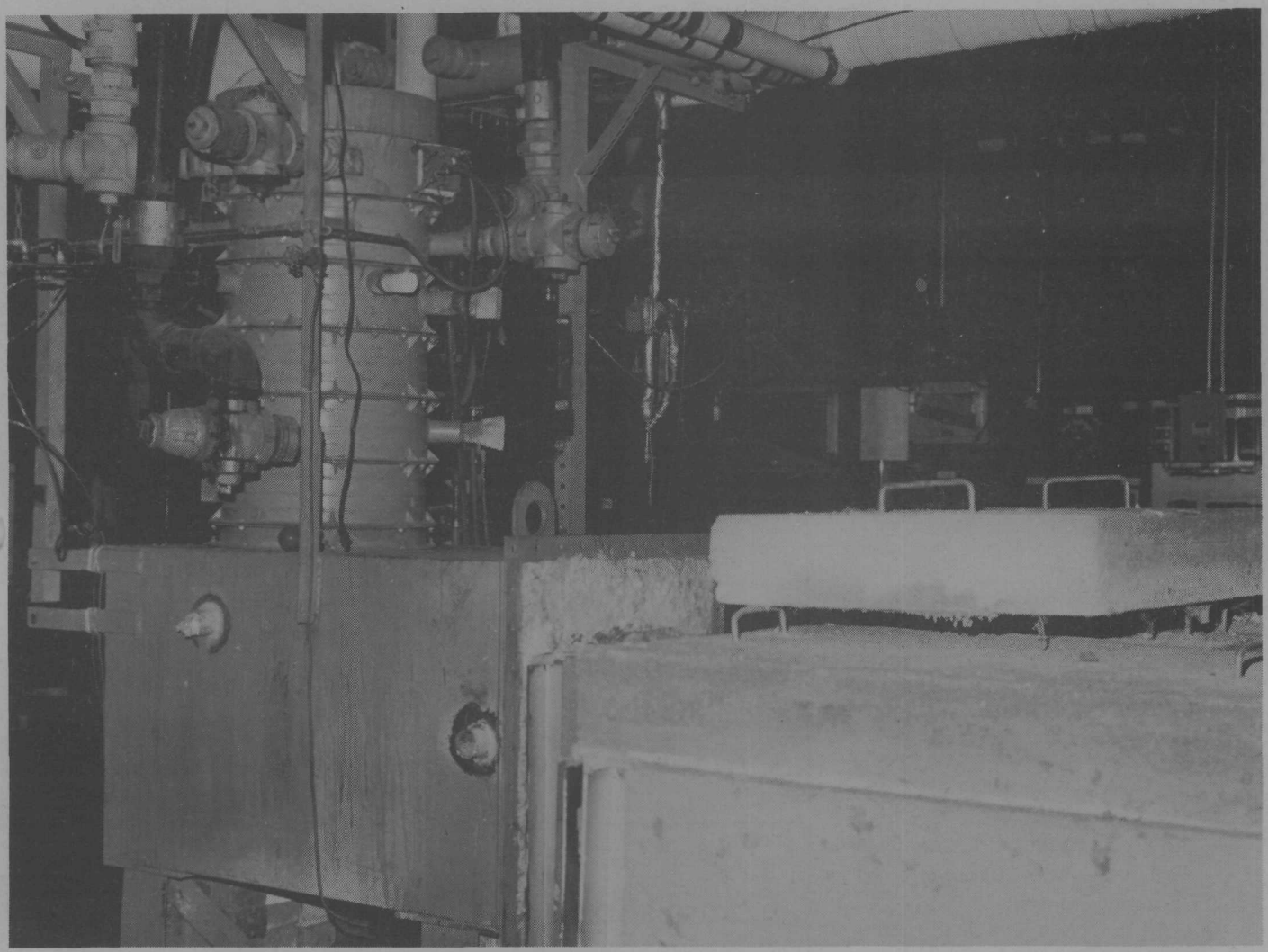
INSTITUTE OF GAS TECHNOLOGY

CYCLIN CYCLONIC INCINERATOR



The CYCLIN incinerator is an advanced, high efficiency, high intensity, cyclonic incinerator for both liquid and gaseous industrial waste destruction. The unit has been jointly developed by the Institute of Gas Technology (IGT) and York-Shipley, Inc. York-Shipley's engineering and manufacturing expertise is complemented by IGT's skills in combustion testing, laboratory evaluation, and pilot-scale testing on candidate wastes.

The utilization of a high intensity, low excess air, cyclonic combustion results in many advantages over current incinerators. Intense combustion results in a unit that is substantially smaller than alternative designs and minimizes the need for auxiliary fuel. The CYCLIN is versatile — it can burn both liquid and gaseous wastes — eliminating the need for costly drying and concentrating operations. It can be operated with either wet (slag) or dry ash removal, making it applicable for wastes with either high or low melting temperature ash. With minor modification, the CYCLIN can also incinerate solid or slurry wastes.

The design of the pilot-scale CYCLIN is flexible; it permits variations in the waste, supplementary fuel, and air injection systems to allow the design of an optimal system for each liquid or gaseous waste, different auxiliary fuels, and alternative methods of combustion air injection. Virtually complete combustion of the waste produces very low levels of CO, unburned hydrocarbons, other toxic gaseous products and (depending upon the waste materials and/or auxiliary fuel) NO_x and SO_x

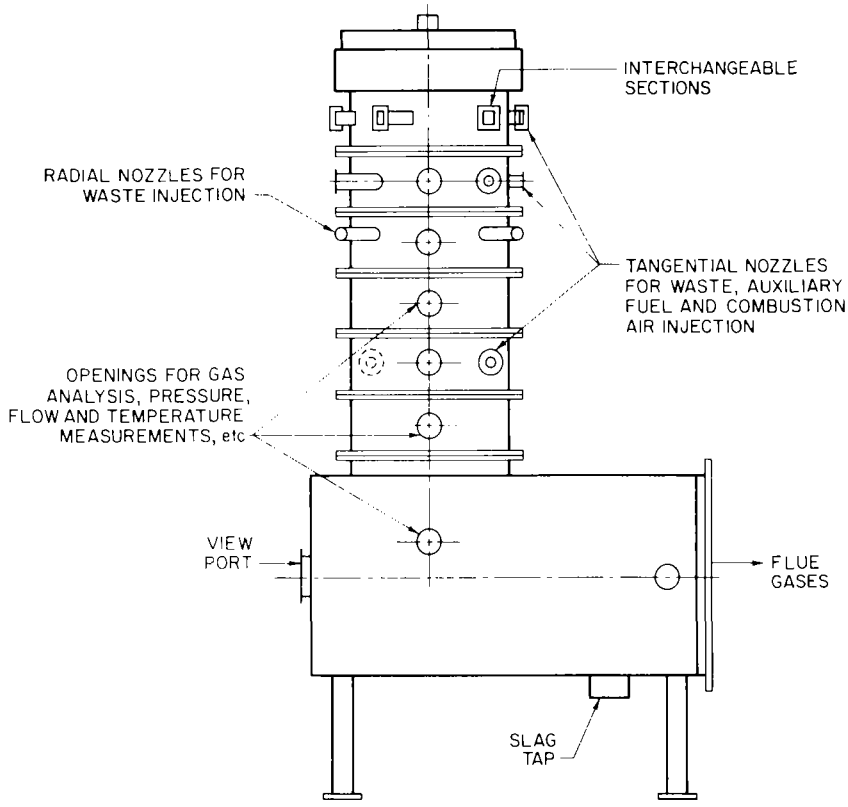
The IGT Applied Combustion Research Facility is available to test wastes and provide design information for specifying an optimal configuration of the CYCLIN unit for each application. Pilot-scale assessment aids in evaluating incinerator performance, and analyzing combustion characteristics of various types of waste, and in investigating emission formation. Complete instrumentation and control of test parameters allow the full characterization of the flame as well as measurement of exhaust gas concentrations of environmentally-sensitive species.

Production units have been installed and are now handling a variety of wastes. Designs are based on tests by IGT using the actual waste material. On request, York-Shipley will provide a firm proposal for the turn-key installation of a CYCLIN Incinerator including all waste, fuel, heat recovery, and pollution control equipment. Lead time, including waste testing by IGT, design by York-Shipley, fabrication, installation, and start-up, is about 10 months.

CYCLIN Characteristics and Advantages

- High intensity, low excess air cyclonic combustion
- Capability to combust a wide variety of liquid and gaseous waste — especially with low fusion temperature of inorganic content
- Efficient ash removal — dry or wet (slag)
- Capability to operate with minimal or no auxiliary fuel
- Capability to utilize waste heat recovery for more efficient process optimization
- Low flue gas emissions
- Small unit size
- Low capital cost
- Short payback period

CYCLONIC INCINERATOR - PILOT-SCALE UNIT



Applications

- General
  - liquid or gaseous industrial wastes with wide variety of organic and inorganic content
- Specific
  - organic and inorganic chemicals
  - petrochemicals and refineries
  - dairies
  - vegetable and fruit canning
  - bakeries
  - sugar and confectionary processing
  - fat and oil extraction
  - beverages (alcoholic and non-alcoholic)
  - yeast, vinegar, syrups, and other food ingredients
  - hospitals
  - other biomass processes

Combustion Test Capabilities (IGT)

- Pilot-Scale Unit has the Flexibility to Vary:
  - type of waste (liquid or gaseous) and auxiliary fuel type
  - fuel firing rate
  - air input rate
  - oxygen enrichment
  - air preheat temperature
  - waste material and fuel preheat temperature
- Instrumentation to Measure:
  - combustion characteristics
  - temperature profiles
  - flow direction profiles
  - flue gas emissions (TSP, NO_x, SO_x, CO, unburned hydrocarbons, etc.)

Contacts:

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CYCLIN INCINERATOR

This document introduces
a new concept
in waste incineration

IGT

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THE CYCLIN INCINERATOR

The CYCLIN incinerator is a new concept in waste destruction that achieves improved performance at lower cost. The waste incineration system has been jointly developed at the Institute of Gas Technology (IGT) and York-Shipley, Inc. (Y-S), integrating advanced combustion principles and system engineering to result in a high intensity, cyclonic incinerator that successfully processes ashing and/or slagging materials as well as more readily processed wastes. The unit is so successful that the first application tested on the pilot scale incinerator resulted in an order for a commercial demonstration facility. In this case, available commercial incinerators had failed to process satisfactorily a liquid waste having a low heating value (3200 Btu/lbm) and high (50%) moisture content; the CYCLIN incinerator processed this waste at high efficiency.

The purpose of this document is to introduce the CYCLIN incinerator, outline its operating principles and design features, and indicate the availability of a pilot system for testing in specific applications. The CYCLIN incinerator is the outgrowth of a cooperative development of the combustion R&D scientists at IGT and the design, engineering, and manufacturing expertise at York-Shipley. The resulting unit is an advanced, high intensity, cyclonic incinerator that provides stable combustion of industrial wastes while minimizing auxiliary fuel usage. The design and testing have resulted in operating features that promote stable, long term, highly efficient operation with minimum operating expense. Some of these characteristics are:

- Incinerator Chamber Geometry: A combustion chamber of circular cross-section with tangential injection of combustion air (and perhaps auxiliary fuel) at the top of the chamber promotes excellent mixing and high swirl. Depending upon the waste characteristics, it may be injected simultaneously with the combustion air into the swirl or at an auxiliary location. Although a variable with waste characteristics, the ratio of chamber diameter to height is approximately 1:2. An orifice-type restriction, or choke, at the chamber bottom enhances the swirl and promotes internal updraft recirculation of the combustion products.

- Use of Premix Burners. The short, intense flame produced by premix burners is advantageous to the cyclonic incinerator because:

  1. Heat is focused near the atomized waste, thereby helping to evaporate any water in the atomized spray and

2. Premix burners permit a small combustion volume, thereby reducing the incinerator unit size and capital cost.

- Ash/Slag Separation. Separation of the ash/slag from the products of combustion is preferred for long term operation of the incinerator unit, as well as heat recovery equipment downstream of the unit. Dry ash, molten ash, and molten slag are flung to the incinerator chamber walls by the centrifugal nature of the cyclonic swirl, thereby removing most of the ash/slag from the combustion products and minimizing clogging and heat transfer performance problems in the heat recovery equipment downstream of the incinerator.

- Increased Refractory Life. Life expectancy of slag-resistant refractory is greatly improved by intentionally cooling the refractory lining of the combustion chamber walls with water or air such that molten slag freezes on the refractory surface. The frozen slag layer protects the refractory from erosion and corrosive effects of the swirling, high velocity combustion products, laden with ash and slag. Molten slag continues to form on the surface of the frozen slag and falls to the chamber bottom for removal.

- Atomizers. Efficient combustion of liquid waste requires its atomization so that mixing of wastes, combustion air, and internally recirculated combustion products is thorough. Pneumatic atomizers produce droplets in the 100 micron range, while mechanical atomizers produce a coarser spray.

- Low Combustion Temperature. Cyclonic incinerators operate at lower temperature units for the same application and thus reduce auxiliary fuel requirements.

Pilot Scale Cyclonic Incinerator Unit

The heart of the pilot scale incineration system installed at the Combustion Research Facility at IGT is the cyclonic incinerator unit. For versatility, the unit consists of interchangeable cylindrical sections atop a base section that serves as an ash/slag receiver. The interchangeable cylindrical sections may be rearranged for more effective incineration, depending upon the characteristics of the specific waste being incinerated. A diagram of the incinerator as assembled for a specific application is shown in Figure 1 and Figure 2 is a photograph of the unit. Figure 2 illustrates the integral combustion air/natural gas manifolding, cooling water piping, and exhaust duct. Each section of the unit incorporates a water-cooled annulus and an interior refractory lining. The individual sections are constructed from carbon steel and are joined with flanges. The approximate size of the incinerator is 2 feet in diameter x 4 feet high, depending upon the application. Figure 3 is a photograph of one of the ring-sections during construction, prior to refractory installation.

CYCLONIC INCINERATOR — PILOT-SCALE UNIT

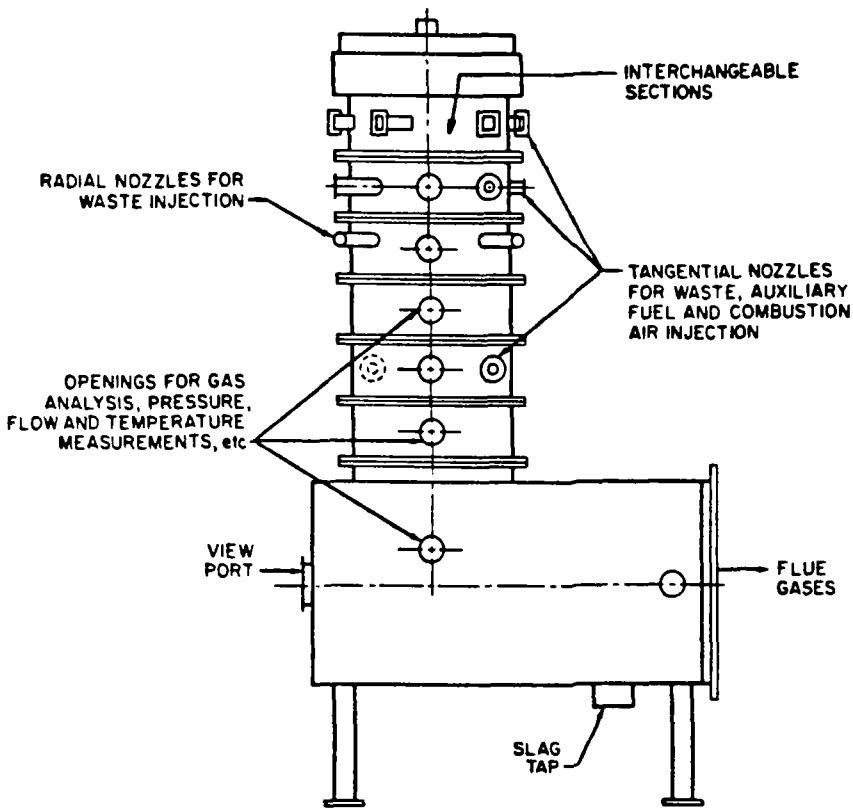

Figure 1. OVERALL VIEW OF MODIFIED CYCLONIC INCINERATOR UNIT

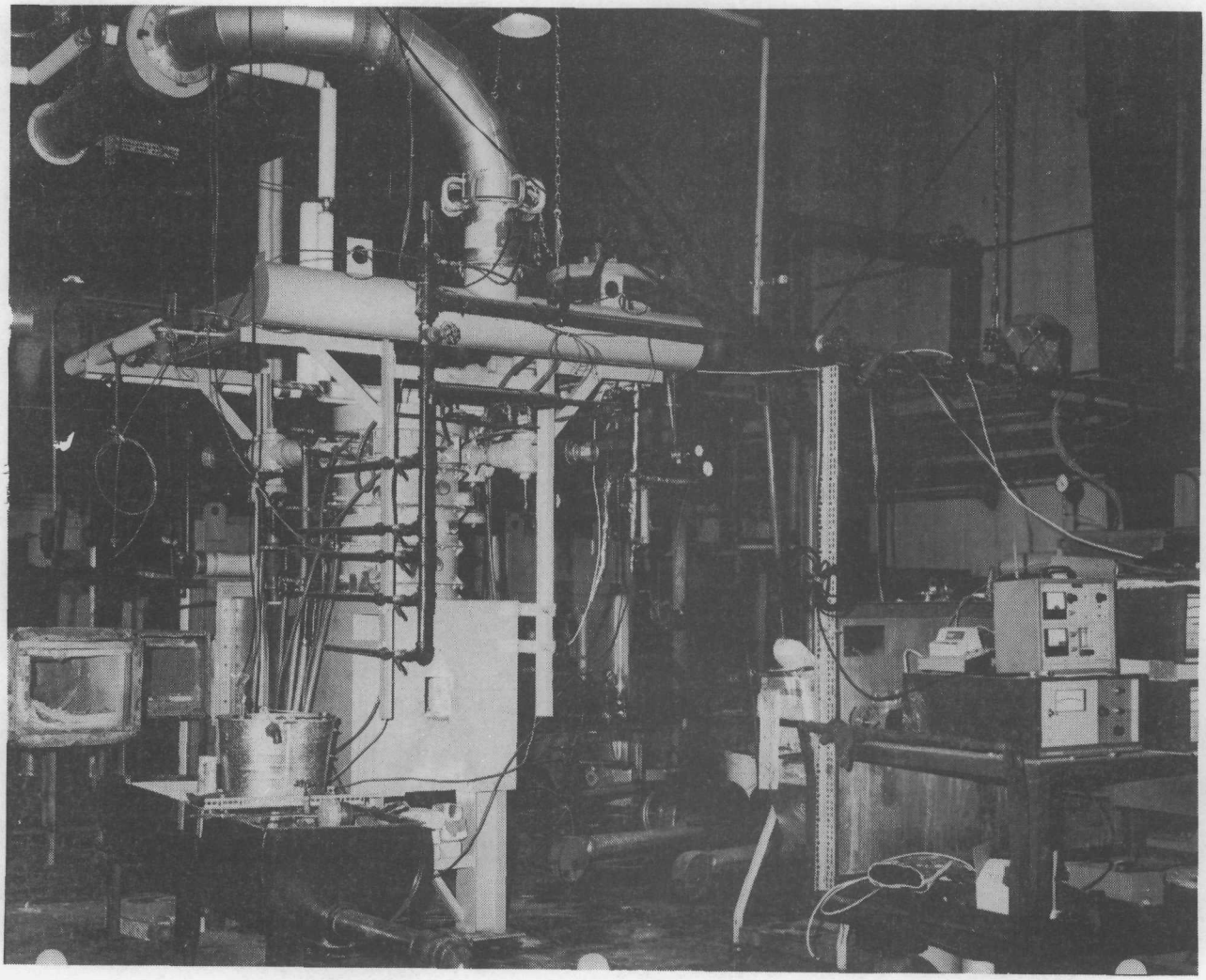

Figure 2. OVERALL VIEW OF CYCLONIC INCINERATOR SYSTEM

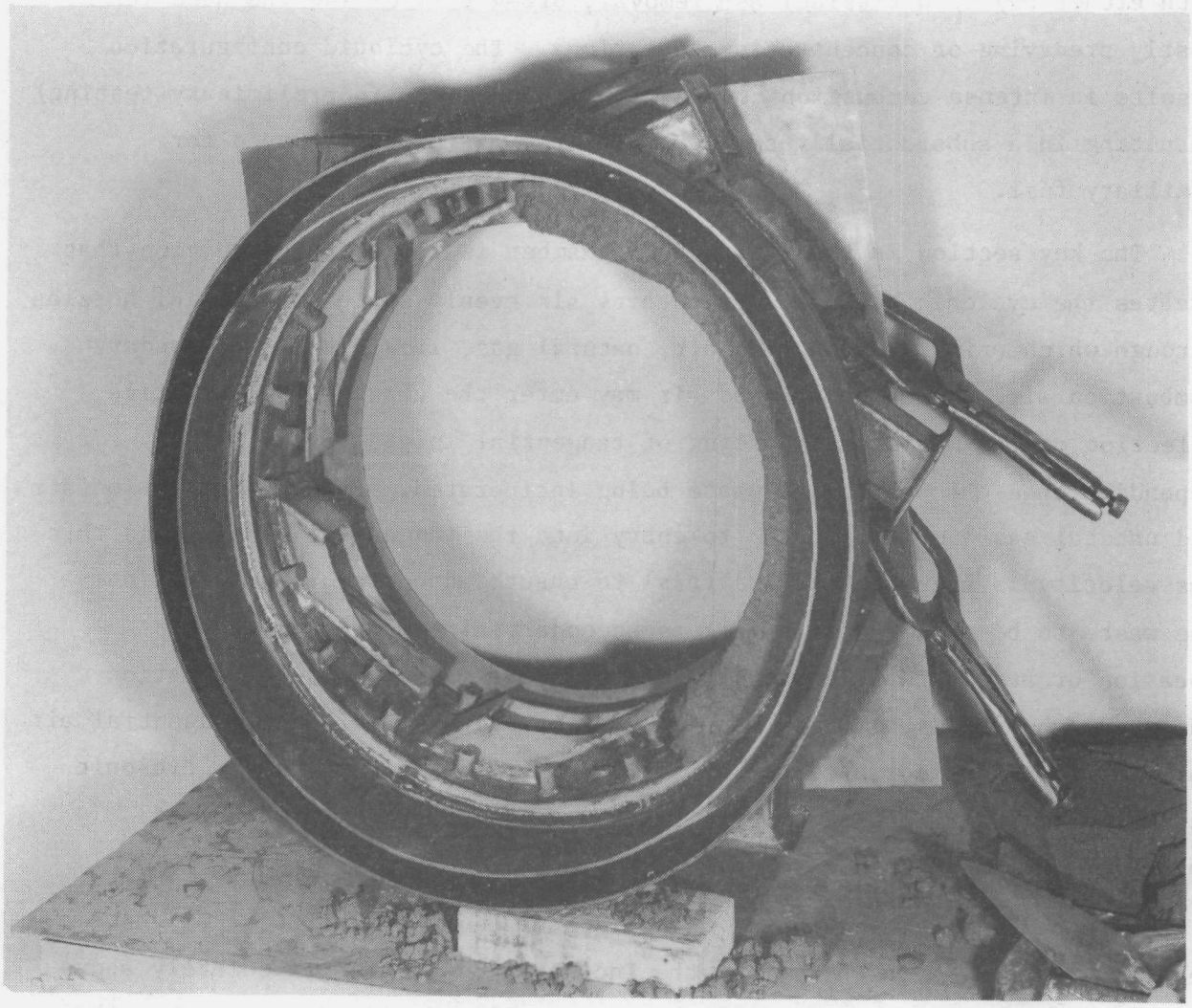

Figure 3. CYCLONIC BURNER SECTION BEING MANUFACTURED BY YORK-SHIPLEY, INC.

A major feature of the pilot scale unit is the flexibility of design and application through rearrangement of the ring sections. This rearrangement permits modifications in the waste feeding and auxiliary fuel injection systems to handle a variety of liquid and gaseous wastes, different auxiliary fuels, and different locations for adding primary and secondary air. The CYCLIN incinerator is capable of burning both liquid and gaseous material, with either dry or wet (slag) ash removal, often eliminating the need for costly predrying or concentrating operations. The cyclonic configuration results in intense combustion (over 300,000 Btu/hr-ft^3 in preliminary testing) resulting in a substantially smaller unit that minimizes the need for auxiliary fuel.

The key section in the incinerator chamber is the top ring-section that creates the cyclonic action. It contains six evenly spaced tangential nozzles through which primary combustion air, natural gas, liquid waste, secondary combustion air, and/or compressed air may enter the chamber. Alternative selection of the number and spacing of tangential inlets is possible, depending upon the particular waste being incinerated. Primary combustion air and natural gas are mixed prior to entry into the tangential nozzles and this gas velocity is high (200 to 300 ft/s) to ensure adequate cyclonic action. The waste to be processed, as well as secondary air, may enter at this location or at alternative rings in the structure. For one configuration employed, the waste atomizers were centrally located within the tangential air inlet nozzles, as indicated in Figure 4. Figure 5 illustrates the cyclonic action achieved in this section, with each flame providing preheat and vaporization for the other flame.

A second chamber section of major importance is the orifice, or choke section, located at the bottom of the incineration chamber immediately above the base/slag receiver. The orifice has a smaller inside diameter than the major portion of the chamber and its purpose is to enhance the cyclone swirl and also to promote recirculation of combustion products to the top of the incineration chamber for recycle of heat.

Other sections of the chamber have various purposes. The top lid is removable to facilitate inspection of the incinerator interior after a test firing. The lid also features a water seal, which helps to maintain a positive pressure in the incinerator during firing. One of the section rings

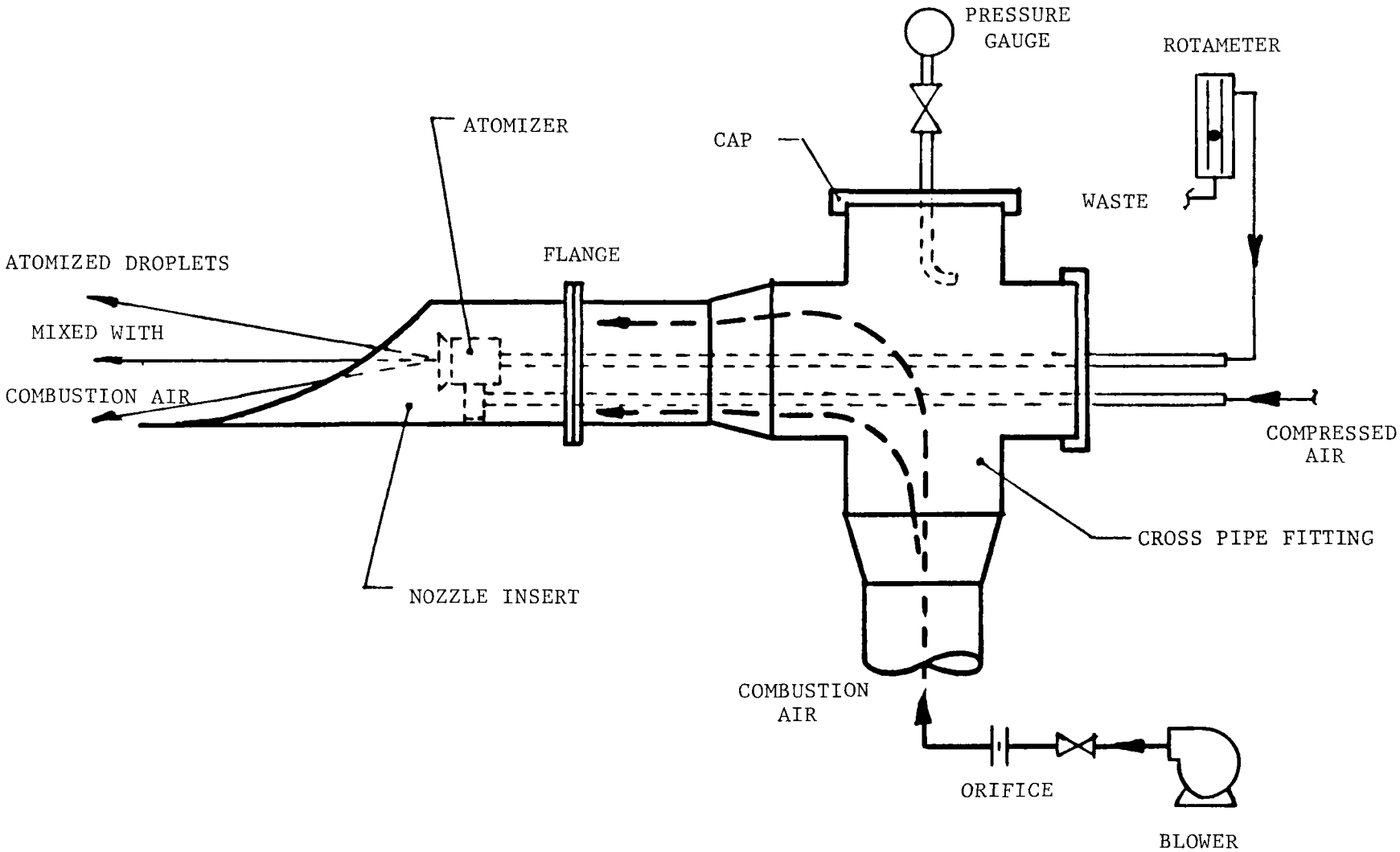

Figure 4. DIAGRAM OF ATOMIZER/NOZZLE ASSEMBLY

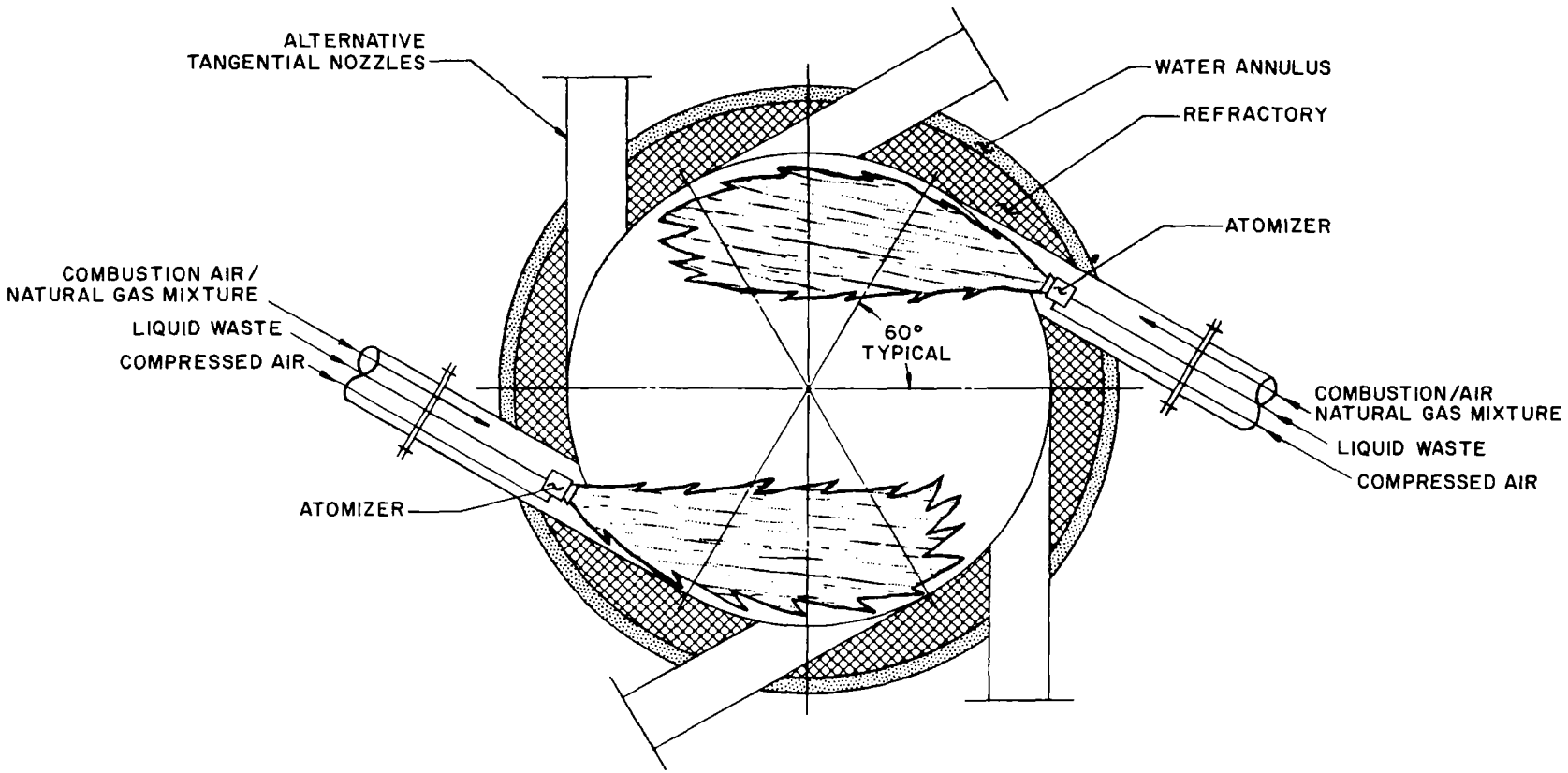

Figure 5. TOP VIEW OF CYCLONIC INCINERATOR BURNER SECTION

includes provisions for radial waste atomizers, additional sections incorporate openings for gathering of data or viewing the cyclone interior. These openings allow entry of water cooled probes for measurement of interior temperature or collecting samples of combustion gases.

A common feature for all incinerator sections is a 1.5 inch thick refractory lining that is attached to the water cooled walls of the annulus by specially designed anchor studs. The refractory is a high alumina/chromium ramming mix that is satisfactory for 3000°F service, chemically inert to slag attack, and mechanically resistant to thermal shock.

Another common feature of the incinerator unit is that cooling water is routed through the circumferential annulus of each section to remove heat from the refractory lining and promote the freezing of molten slag on the refractory face. Each annulus has baffles and wall protrusions that promote good water distribution within the annulus; each section has a bottom inlet and a top outlet to eliminate dry spots and prevent entrapment of steam bubbles.

Auxiliary Equipment

Figure 6 is a schematic diagram of the 1 million Btu/hr test station installed at the IGT Applied Combustion Research Facility. The system is capable of operating with ambient air, or preheat to 800°F. Feed storage includes mixing, recycle, and heating capability to assure uniformity and, if necessary, preheating of the waste material to be processed. Both compressed air and steam are available for liquid waste atomization. A full range of instrumentation is available for measurements of flows, temperatures, gas compositions, and contaminant levels.

Summary

In summary, a novel incineration system, jointly developed by IGT and York-Shipley, promises improved performance in the destruction of waste products. In its first test program, on a waste material that could not be satisfactorily processed in existing commercial equipment, it operated so well that a demonstration/commercial system was ordered.

Because of its unique configuration, promoting cyclonic combustion with internal recirculation, the system has now shown, without comprehensive testing:

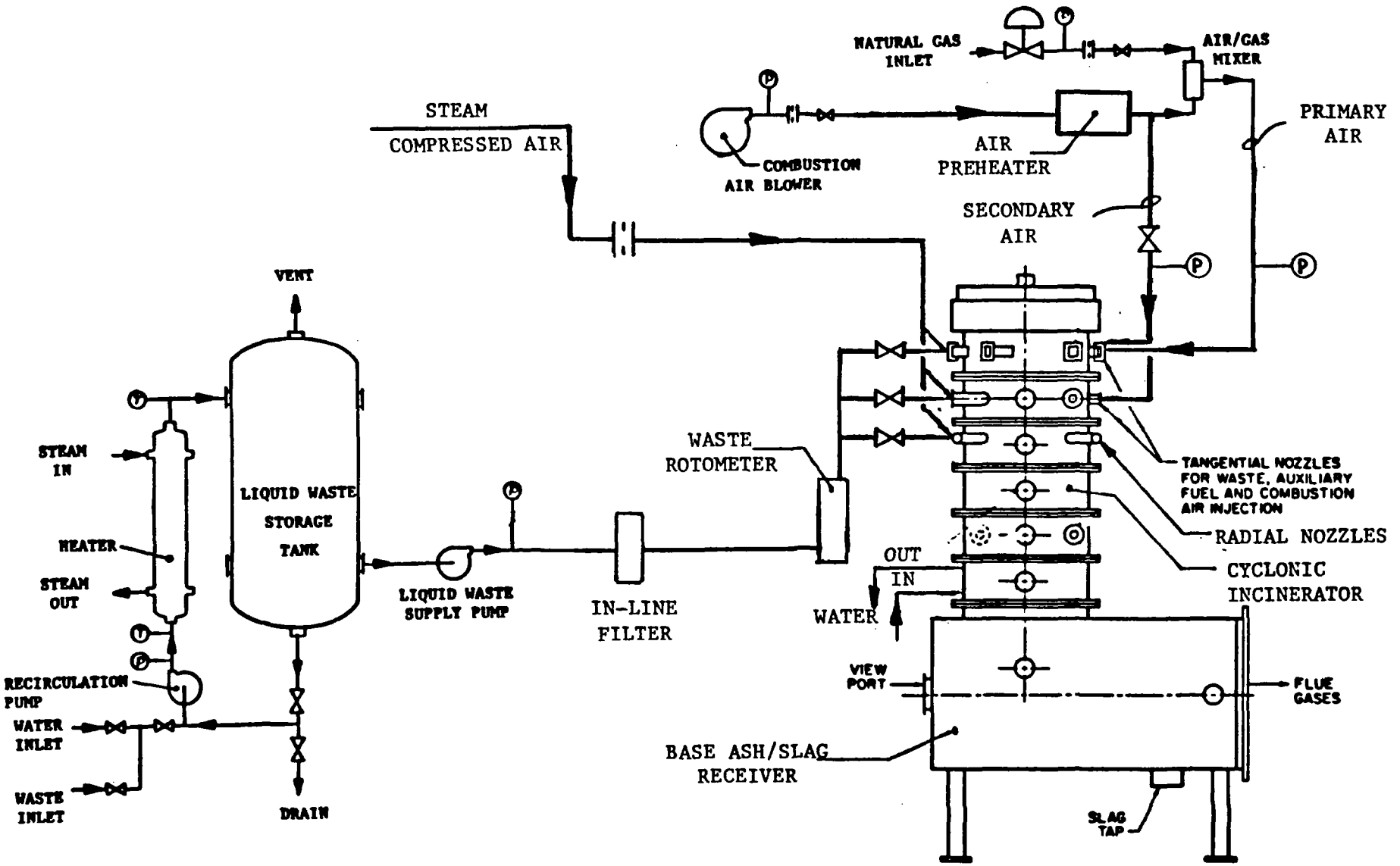

Figure 6. SIMPLIFIED SCHEMATIC DIAGRAM OF PILOT SCALE CYCLONIC INCINERATION SYSTEM INSTALLED AT IGT'S APPLIED COMBUSTION RESEARCH FACILITY

- High combustion intensity: Greater than 300,000 Btu/hr-ft^3 for natural gas firing and up to 200,000 Btu/hr-ft^3 for waste incineration.
- Combustion efficiency: Less than 25 ppm CO at 3%-5% excess air for natural gas firing and less than 100 ppm CO at 10%-15% excess air for waste incineration.
- Low thermal NO_x production: Less than 80 ppm at 2600°-2700°F
- High incineration efficiency: Less than 25 ppm unburned hydrocarbons
- Dry or wet (slagging) operation, with no degradation to refractory
- High turn down ratios: Greater than 3.5:1.

The constructional characteristics of the pilot scale unit permit modification of the configuration for optimization of the system on each application. These variations include:

- Operation with ambient or preheated air
- Variation of amount of primary to secondary combustion air, with capability for air staging
- Alternative locations for injection of waste to be incinerated
- Operation on gaseous or liquid wastes. With modification, it is anticipated that slurry or solid wastes could be satisfactorily processed
- Operation with auxiliary fuel, if required. It is anticipated that such fuel could be solid, liquid, or gaseous.

In the optimization program on the first waste to be treated, the auxiliary fuel requirements were reduced from 150% to 67% of the heating value in the waste materials. This waste material contained 50% water that must be evaporated before the waste would burn, yet the combustion intensity was so high that incineration was virtually complete.

The complete test facility at the Applied Combustion Research Laboratories at IGT is available for testing of waste material to be incinerated. York-Shipley will design and fabricate commercial incinerators based upon test data obtained. Further, York-Shipley will engineer and fabricate the total system, including waste heat recovery, as required for a turn-key process.